

DEVELOPMENT OF A ROCKET RECOVERY SYSTEM

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Thesis submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

JANUARY 2013

ABSTRACT

The design, fabricate and testing of a rocket recovery system is presented in this report. Recovery system is important for a rocket for low cost of fabricating the rocket and the flight data analysis. The recovery system chosen for the rocket is a parachute recovery system. The recovery system is divided into two parts; the parachute and the ejection system. In this report, six different designs are fabricated. Drop test of the parachutes was conducted to find the design for the parachute. The test shows that the semi-ellipsoidal parachute is the best parachute that can support an empty rocket mass of 2.5kg with the descent range is 5.98m/s. The parachute recovery system constructed in this project will be integrated with the rocket body and powered by a solid propellant rocket motor.

ABSTRAK

Reka bentuk, fabrikasi dan ujian sistem pemulihan roket dibentangkan dalam laporan ini. Sistem pemulihan adalah penting untuk roket untuk kos rendah reka roket dan analisis data penerbangan. Sistem pemulihan dipilih untuk roket adalah sistem pemulihan payung terjun. Sistem pemulihan dibahagikan kepada dua bahagian; payung terjun dan sistem pelepasan. Dalam laporan ini, enam reka bentuk yang berbeza direka. Ujian jatuh payung terjun telah dijalankan untuk mencari reka bentuk terbaik bagi payung terjun. Ujian menunjukkan bahawa payung terjun semi-elipsoid adalah payung terjun terbaik yang boleh menyokong jisim roket kosong 2.5kg dengan pelbagai keturunan adalah 5.98m / s. Sistem payung terjun pemulihan dibina dalam projek ini akan diintegrasikan dengan badan roket dan dikuasakan oleh motor roket berpropelen pepejal.

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LIST OF SYMBOLS

F_d	Drag force
ρ	Air density
C_D	Drag coefficient
m	Payload mass
g	Gravitational force
V	Descent velocity
A	Surface area
D_o	Nominal diameter
D_p	Parachute diameter
L_{root}	Length of the fin at the root
L_{tip}	Length of the fin at the tip
S	Span of the fin
D	Airframe diameter
T_{root}	Thickness of the fin at the root
T_{tip}	Thickness of the fin at the tip
L_{cave}	The length of the fin at the centre
m	Mass
P	Pressure
V	Volume
R	Air combustion constant
T	Temperature

LIST OF ABBREVIATIONS

UMP	Universiti Malaysia Pahang
PDS	Parachute Development System
B. C.	Before century
NASA	National Aeronautics and Space Administration
PVC	Polyvinyl Chloride
PSM	Projek Sarjana Muda
UAV	Unmanned Aerial Vehicle
NARAM - 41	41 st National Association of Rocketry Research and Development

CHAPTER 1

INTRODUCTION

1.1 PROJECT TITLE

Development of a rocket recovery system.

1.2 PROJECT BACKGROUND

Rocketry is the art of making rockets. It covers all aspects from theory to research to development to launching. Rockets have evolved from gunpowder rockets used by ancient Chinese to giant, complex thrust engines capable of bringing mankind to the moon. There are many types of rockets usage in this modern era; tactical missiles, space launch vehicles, sounding rockets, etc.

The aim of the research is to design and fabricate the complete system of a rocket recovery system. The recovery system of a rocket is very important since it can save the cost of rocket fabricating. Other than that, the recovery system of a rocket also will help the researcher to study the characteristics of flight analysis that have been brought back in the rocket by the recovery system.

1.3 PROJECT OBJECTIVE

The objective of the project is to design, fabricate and testing the rocket recovery system.

1.4 PROJECT SCOPE

The scopes of the project are

- i. Design and fabricate design system
- ii. Conduct the experiment test
- iii. Data analysis and report writing

1.5 PROBLEM STATEMENT

Rocketry is often seen as a sport or a hobby in countries such as the United States, the United Kingdom, Germany, Japan, Russia, Spain and France. It is a hobby practised by young and old and is often used as an educational tool for school children. Rockets are practically built off their backyard. Having developed with interest in rocketry at such young age, these school children are the human resources that propelled these countries to technological advancement in the field of aerospace engineering.

Unfortunately for Malaysia, school children are not taught about rocketry, neither is rocketry a common hobby among the old. Often deemed as weapons of war, rocketry actually brings a lot of benefit to the community. Rather than just being a hobby and an educational tool, sounding rockets provide an option for scientist to study about weather and perform many other experiments during its sub-orbital flight.

1.6 REPORT OUTLINE

The report on this study is divided into five chapters. Chapter 1 provides the general introduction on the study and it includes the objectives, scopes, and outline report of the study was briefly explained.

Chapter 2 presents literature reviews on rocket recovery system. The reviews start with the history and development of rocket technology around the world. The discussion on basic theory of the rocket such as rocket parts is briefly discussed. This chapter also discussed about rocket recovery system design and also rocket recovery ejection system.

Chapter 3 starts with the flowchart of the study. This chapter explains about rocket parachute designing. It also includes the fabrication of deployment system.

Chapter 4 explained about tests that have been carried out during this study. This includes parachute drop test and also ejection charge test.

Lastly, chapter 6 summarized several conclusions and recommendations that could be considered for the next researcher to improve and advancing further the research on development of a rocket recovery system.

CHAPTER 2

LITERATURE REVIEW

2.1 ROCKET HISTORY

One of the first devices to successfully employ the principles of rocket flight was a wooden bird. Aulus Gellius, a Roman, tell a story of a Greek named Archytas who lived in the city of Tarentum, around the year 400 B.C. Archytas had amused the citizens by flying a wooden pigeon made of wood. Escaping steam propelled the bird suspended on wires. The pigeon used the action-reaction principle, which was not to be stated as a scientific law until the 17th century. [1]



Figure 2.1: Hero engine [1]

About three hundred years after the pigeon, another Greek, Hero of Alexandria, invented a similar rocket-like device called an aeolipile. It, too, used steam as a propulsive gas. Hero mounted a sphere on top of a water kettle. A fire below the kettle turned the water into steam, and the gas traveled through pipes to the sphere. Two L-shaped tubes on opposite sides of the sphere allowed the gas to escape, and in doing so gave a thrust to the sphere that caused it to rotate. [2]

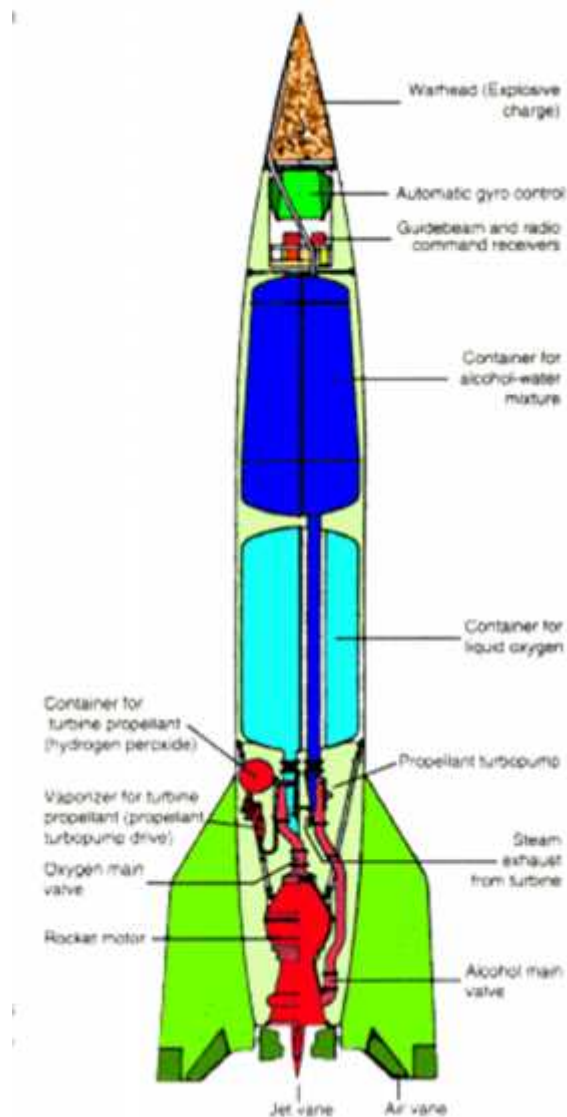


Figure 2.2: German V-2 (A-4) missile [2]

The V-2 rocket (in Germany called the A-4) was small by contrast to today's rockets. It achieved its thrust by burning a mixture of liquid oxygen and alcohol. Once launched, the V-2 was a frightening weapon that could destroy whole city blocks. Fortunately for London and the Allied forces, the V-2 came too late in the war to change its result. United States recognized the potential of rocketry as a military weapon and began a variety of experimental programs. At first, the United States began a program with high-altitude atmospheric sounding rockets. Later, they developed a variety of medium- and long-range worldwide ballistic missiles. These became the starting point of the U.S. space program. Missiles such as the Redstone, Atlas, and Titan would eventually launch astronauts into space. Soon, rockets launched many people and machines into space. Astronauts orbited Earth and landed on the Moon. Robot spacecraft traveled to the planets. Satellites enabled scientists to investigate the world, forecast the weather, and communicate instantly around the earth. The demand for more and larger payloads created the need to develop a wide array of powerful and versatile rockets. [2]

2.2 ROCKET PARTS

These are parts includes in a model rocket namely; nosecone, payload compartment, body tube, launch lug, fins, and motor tube for solid rocket motor.

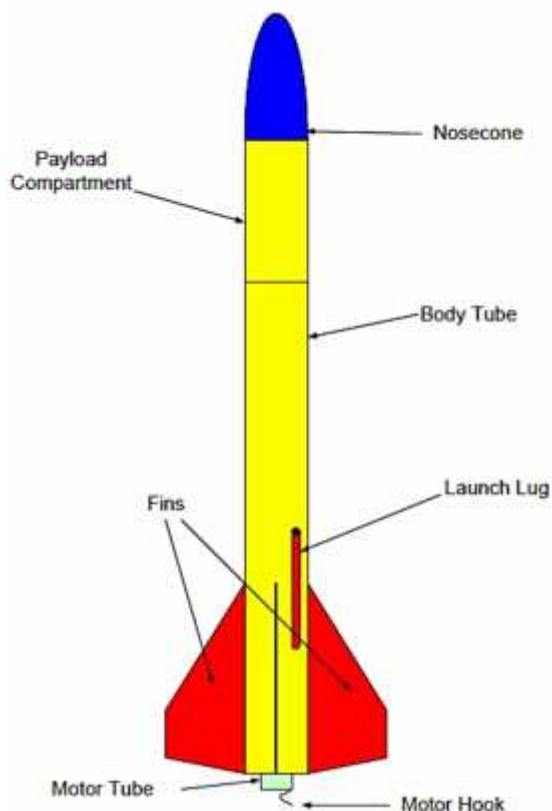


Figure 2.3: Major parts of a rocket [3]

The nosecone has an aerodynamic shape. Normally, nosecones are parabolic or ogive as these shapes performs well at lower speeds. For really high speed rockets a slender conical nosecone is ideal. Nosecone may also hold payload. The payload compartment is for carrying altimeters, cameras, experiments or other payloads. It is an extension to the body tube, but separated from the main body tube by a sealed bulkhead. It connects the payload compartment to the lower body tube. The bulkhead also prevents hot gases from leaking into the payload and damaging experiments. Altimeter measures the changing air pressure to calculate apogee.

The body tube contains parachute and shock cord. Parachute assists in the safe recovery of the rocket. A shock cord connects the parachute to the nosecone. It absorbs the shock of ejection charge and it is attached with a shock cord attachment which has a metal eye for the secure attachment of the shock cord. The launch lug is a hollow tube that is glued to the rocket around its point of balance. This slips over the launch rod, which keeps the rocket pointing upwards as it accelerates. It helps to guide the rocket upward until it reaches enough velocity for the fins to deploy.

Fins are attached to the body tube to make the rocket aerodynamically stable. The fins guide the rocket in a straight path. A motor mount is installed inside back of the body tube. An engine mount holds the rocket engine inside the rocket and an engine retainer prevents the engine from being ejected by the ejection charge.

2.3 ROCKET DESIGN

A rocket had been design based on the guidelines. The rocket should include nosecone, body frame and fins.

2.3.1 Nosecone

Nosecone and fins are one of the crucial aerodynamic components of a rocket. A simple nosecone on top of a rocket is enough to reduce the friction of the rocket. However, more complex shapes may be used to improve the performance of the rocket. There are many common shapes used for nosecone.

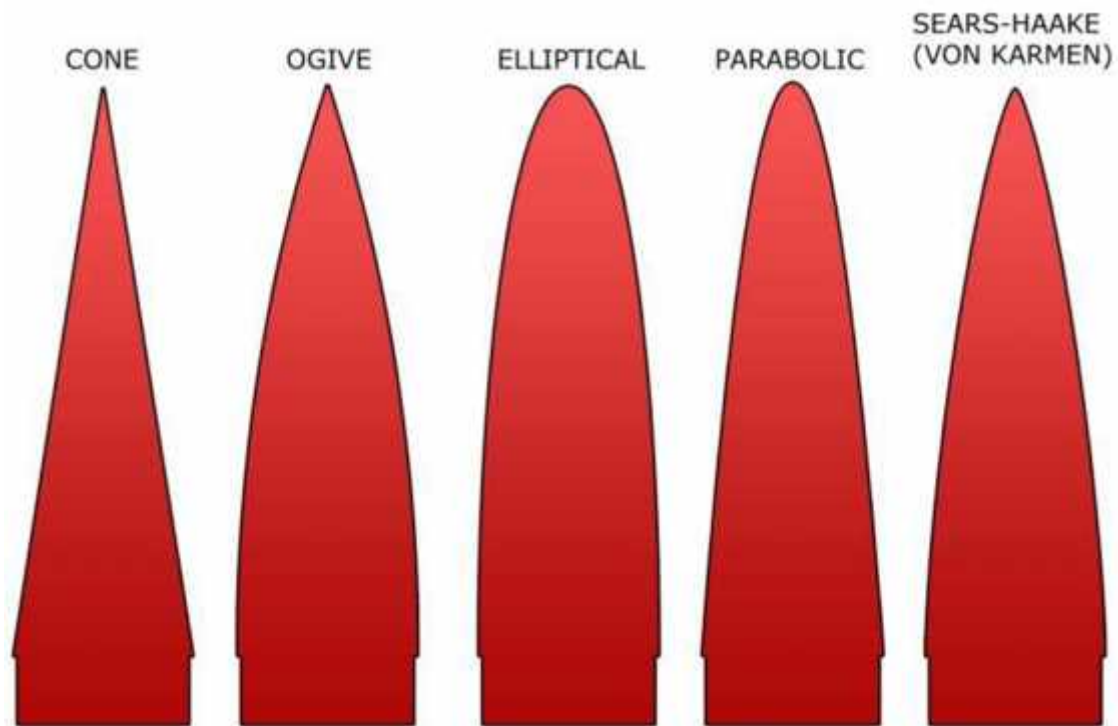


Figure 2.4: Common shapes of nosecone [4]

Nosecone is the tip of the rocket and aerodynamic leading edge. The nosecone has an impact on the characteristic of the rocket. The nosecone also helps to deploy the recovery system allowing the rocket to come back to earth smoothly. When the nosecone is ejected, it will pull the recovery system out of the rocket to allow it to deploy. As such,

the nosecone must fit into the rocket body rather than loosely because if it becomes stuck, the recovery system will not deploy and the rocket will probably lose.

2.3.2 Fins

Fins are important components in building rockets. Because fins give stability, it is important to understand the effect of fins on rocket stability. Fins ensure that the rocket travels in a straight line during flight. It is important to attach the fins firmly to the rocket. A rocket that loses its fins will lose directional stability, causing it to tumble or crash. This is not only cause dangerous, but will result in destruction of the rocket and its payload.

A rocket needs at least three fins to stable. Some would argue that four fins is the optimum number. However many fins attached to the rocket, they should be evenly spaced around the body tube. Fins can be rounded, triangular, square, or any number of different shapes. The important thing is that they are strong enough to take the flight loads. Generally this means using a fin material that is thick enough and strong enough.

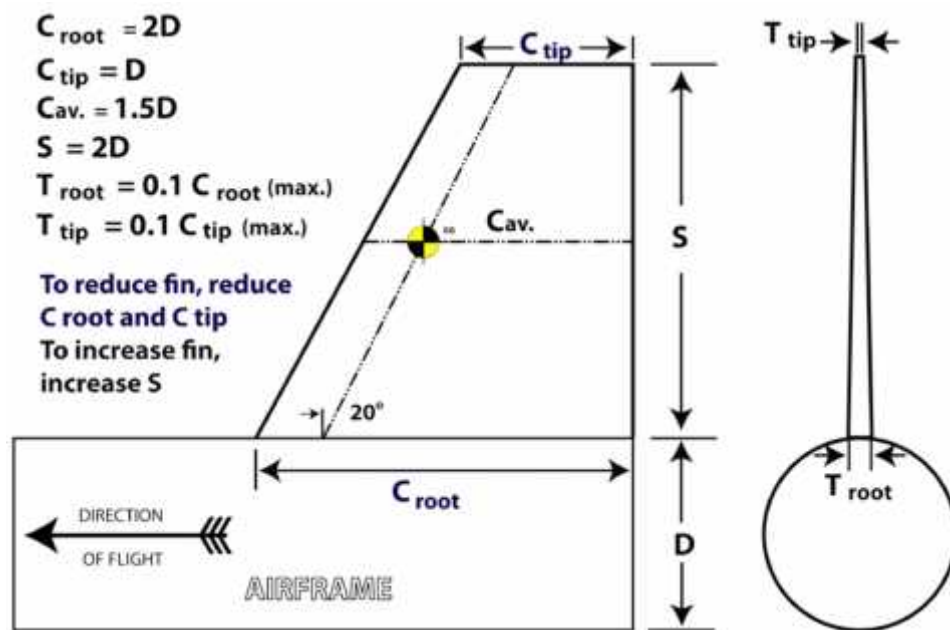


Figure 2.5: Low drag clipped delta fin [4]

These are steps to determine the dimensions of low drag fin:

- i. Determine the diameter of the airframe.
- ii. Multiply it by 2 to determine the root length and the span (C_{root} and S).
- iii. The length of the tip (C_{tip}) is equal to the airframe diameter.
- iv. The thickness of the fin at the root (T_{root}) = 0.1 of the root length (C_{root}).
- v. The thickness of the fin at the tip (C_{tip}) = 0.1 of the tip length (C_{tip}).
- vi. To reduce the fin, reduce the C_{root} and C_{tip} only.
- vii. To increase the fin, increase the span (S) only.

2.3.3 Body Frame

There are several inexpensive and strong specialist tubes that can be used in model rocketry. Spiral wound tubes are purpose made for model rocketry. If it is a need a stiffer rocket then tubes with thicker walls are used. Kitchen roll tubes or domestic materials neither are nor recommended. It would not be strong enough to take the forces on a rocket and will crumple in flight.

The purpose of the airframe tube is to hold the internal stuff. In other words, it keeps the stuff on the inside from falling out of the rocket. It also separates the drag-reducing nose cone from the fin section. If they are too close (in other words, the rocket is very short), the model could be unstable when it is launched. The airframe tube is a flight critical item. That means that if it should bend while the rocket is traveling upward, the flight will go out of control and unstable. The result will be a crash. The tube usually made of PVC tube. But some bigger rockets are made from other materials, like fiberglass, to make it hard and stiff. But for most rockets, PVC tube is plenty strong. PVC tube is actually very durable.

2.4 PARACHUTE RECOVERY SYSTEM

The recovery system is one of the most important parts of a model rocket. It is designed to provide a safe and return the rocket and its payload to earth. It is also to avoid damage the rocket or presenting a hazard to person on the ground. Most recovery systems in use today depend on aerodynamic drag to slow the rocket.

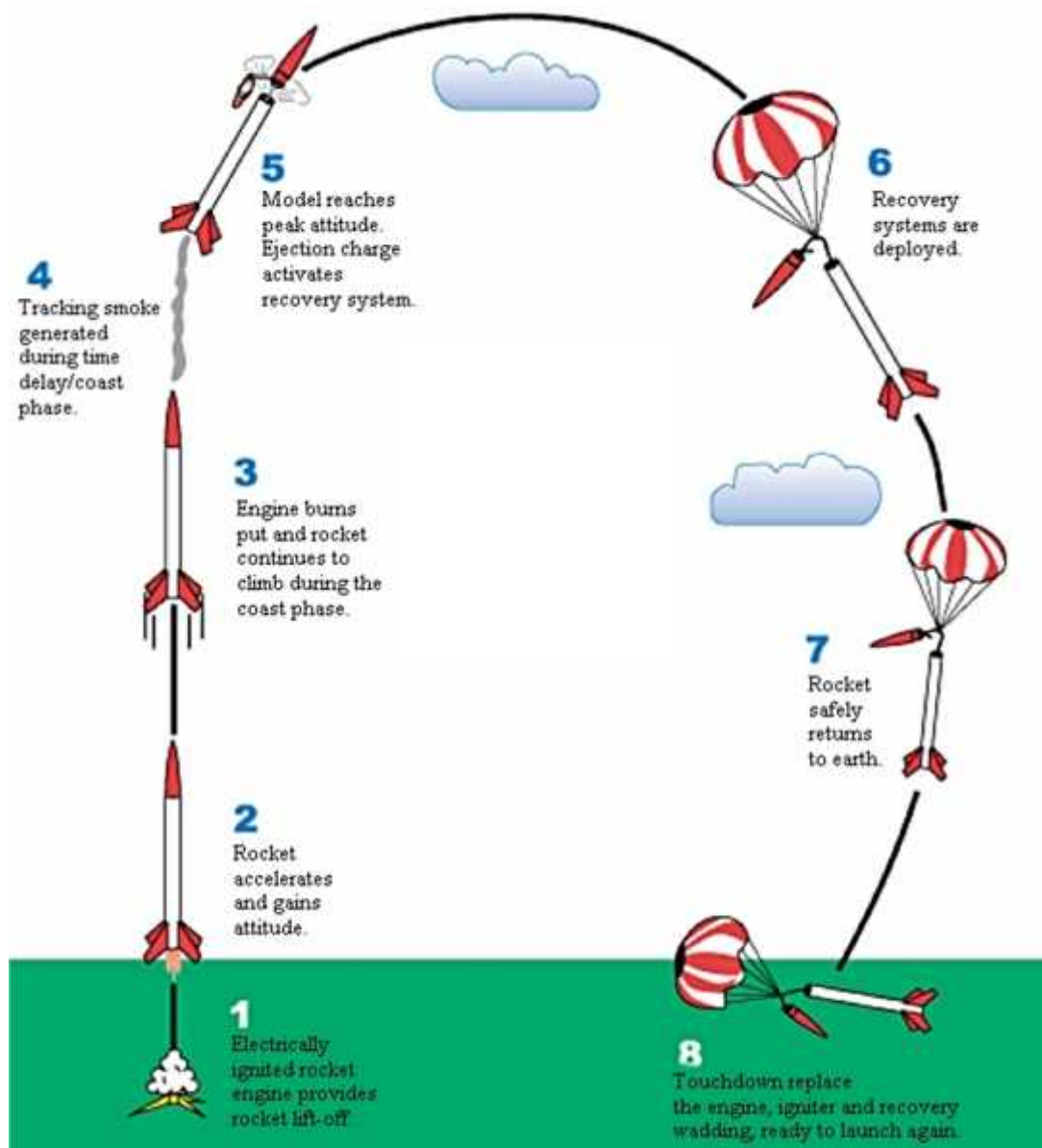


Figure 2.6: Model rocket flight profile [5]